Claims

What is claimed is:

1. A piezoelectric bending actuator comprising:

a first piezoelectric layer adapted to bend in response to an applied voltage;

a second piezoelectric layer adapted to flatten in response to an applied voltage, the second piezoelectric layer mounted adjacent the first piezoelectric layer, the first and second piezoelectric layers moving opposite to each other in response to a change in temperature such that the piezoelectric bending actuator is stable over a range of temperatures.

2. The actuator according to claim 1, wherein the first and second piezoelectric layers are compressed and retained in a housing.

3. The actuator according to claim 1, wherein the first and second piezoelectric layer are compressed and retained in a housing along an outer peripheral edge.

4. The actuator according to claim 1, wherein the first and second piezoelectric layers are polarized opposite to each other.

5. The actuator according to claim 1, wherein an aperture extends through the center of the first and second piezoelectric layers.

6. The actuator according to claim 1, wherein the first piezoelectric layer has a first surface and a second surface, a first electrode mounted to the first surface and a second electrode mounted to the second surface, the second piezoelectric layer having a third surface and a fourth surface, a third electrode mounted to the third surface and a fourth electrode mounted to the fourth surface.

7. The actuator according to claim 6, wherein a terminal is mounted between the second and third electrodes.

8. The actuator according to claim 6, wherein a terminal is mounted to the first electrode and another terminal is mounted to the fourth electrode.

9. The actuator according to claim 6, wherein the first, second, third and fourth electrodes are formed from a rigid metal, the electrodes being glued to their respective surfaces.

10. The actuator according to claim 6, wherein the first and fourth electrodes are formed from steel and the second and third electrodes are formed from a perforated copper foil.

11. An actuator comprising:

a first piezoelectric layer having a top side and a bottom side, the first piezoelectric layer having a first polarity;

a second piezoelectric layer having a top side and a bottom side, the top side of the second piezoelectric layer adjacent the bottom side of the first piezoelectric layer, the second piezoelectric layer having a second polarity, the second piezoelectric layer polarity being opposite that of the first piezoelectric layer, the first and the second piezoelectric layers having opposite temperature responses such that such that the piezoelectric bending actuator is stable over a range of temperatures.

12. The actuator according to claim 11, wherein the first and second piezoelectric layer are compressed and retained in a housing.

13. The actuator according to claim 11, wherein an aperture extends through the center of the first and second piezoelectric layers.

14. The actuator according to claim 11, further comprising:

a first electrode mounted to the first piezoelectric layer top surface;

a second electrode mounted to the first piezoelectric layer bottom surface;

a third electrode mounted to the second piezoelectric layer top surface; and

a fourth electrode mounted to the second piezoelectric layer bottom surface.

15. The actuator according to claim 14, wherein a first terminal is mounted between the second and third electrodes.

16. The actuator according to claim 14, wherein a second terminal is mounted to the first electrode and a third terminal is mounted to the fourth electrode.

17. The actuator according to claim 14, wherein the first and fourth electrodes are formed from steel and the second and third electrodes are formed from a perforated copper foil, the electrodes being fastened to the piezoelectric layers with an adhesive.

18. A piezoelectric actuator comprising:

at least one first piezoelectric disc adapted to bend in response to an applied voltage;

at least one second piezoelectric disc adapted to flatten in response to the applied voltage, the second piezoelectric disc mounted adjacent the first piezoelectric disc;

the first and second piezoelectric discs moving between a first position and a second position in response to the applied voltage, the difference between the first and second positions defining a displacement, the piezoelectric discs reacting to changes in temperature such that the displacement is insensitive to temperature changes; and

a housing, the first and second piezoelectric discs mounted in the housing.

19. The actuator according to claim 18, wherein in response to an increasing temperature, the first and second piezoelectric discs flatten.

20. The actuator according to claim 18, wherein in response to a decreasing temperature, the first and second piezoelectric discs bend more.

21. The actuator according to claim 18, wherein in response to a change in temperature the first and second piezoelectric discs move to offset each other such that no net displacement results.

22. An actuator comprising:

a first dome shaped piezoelectric disc having a first concave surface and a first convex surface, the first piezoelectric disc adapted to bend in response to an applied voltage;

a second dome shaped piezoelectric disc having a second concave surface and a second convex surface, the second piezoelectric disc adapted to flatten in response to an applied voltage; and

the first and second convex surfaces mounted adjacent each other.

23. The actuator according to claim 22, wherein the first and second piezoelectric discs are mounted in a housing.

24. The actuator according to claim 22, wherein the first and second piezoelectric discs having an outer peripheral edge and a center portion, a hole extending through the discs in the center portion, the piezoelectric discs connectable with a movable object through the hole.

25. The actuator according to claim 22, wherein in response to a change in temperature the first and second piezoelectric discs bend or flatten such that the motion of the first disc offsets the motion of the second disc.

26. The actuator according to claim 22, further comprising:

a third dome shaped piezoelectric disc having a third concave surface and a third convex surface, the third piezoelectric disc adapted to bend in response to an applied voltage;

a fourth dome shaped piezoelectric disc having a fourth concave surface and a fourth convex surface, the fourth piezoelectric disc adapted to flatten in response to an applied voltage;

the third and fourth convex surfaces mounted adjacent each other; and

the second concave surface mounted adjacent the third concave surface.

27. The actuator according to claim 26, further comprising:

a first terminal affixed to the first concave surface;

a second terminal affixed between the first and second convex surfaces;

a third terminal affixed between the second concave surface and the third concave surface;

a fourth terminal affixed between the third and fourth convex surfaces; and

a fifth terminal affixed to the fourth concave surface.

28. An actuator comprising:

a first dome shaped piezoelectric disc having a first concave surface and a first convex surface;

a second dome shaped piezoelectric disc having a second concave surface and a second convex surface, the first and second convex surfaces mounted facing each other;

a third dome shaped piezoelectric disc having a third concave surface and a third convex surface;

a fourth dome shaped piezoelectric disc having a fourth concave surface and a fourth convex surface;

the third and fourth concave surfaces mounted facing each other; and

the second concave surface mounted adjacent the third convex surface.

29. The actuator according to claim 28, further comprising:

a first terminal mounted adjacent the first concave surface;

a second terminal mounted between the first and second convex surfaces;

a third terminal mounted between the second concave surface and the third convex surface;

a fourth terminal mounted between the third and fourth concave surfaces; and

a fifth terminal mounted adjacent the fourth convex surface;

30. The actuator according to claim 29 wherein a first voltage is applied to the first and fifth terminal, a second voltage is applied to the third terminal and a third voltage is applied to the second and fourth terminals.

31. A piezoelectric bending actuator comprising:

a ring;

a retainer; and

a plurality of piezoelectric discs held in compression between the ring and the retainer, the mounting of the discs in compression preventing operation of the discs in a state of tension.

32. The piezoelectric bending actuator according to claim 31, wherein the piezoelectric discs are held between the ring and retainer along an outer edge such that a center of the piezoelectric discs are free to move.

33. The piezoelectric bending actuator according to claim 31, wherein the ring and retainer are mounted in a housing.

34. The piezoelectric bending actuator according to claim 31, wherein the piezoelectric discs comprise four piezoelectric discs.

35. The piezoelectric bending actuator according to claim 31, wherein the piezoelectric discs comprise a first, second, third and fourth piezoelectric disc, the first and second piezoelectric discs having adjacent convex surfaces and the third and fourth piezoelectric discs having adjacent convex surfaces, the second and third piezoelectric discs having adjacent concave surfaces.

36. The piezoelectric bending actuator according to claim 31, wherein the piezoelectric discs comprise a first, second, third and fourth piezoelectric disc, the first and second piezoelectric discs having adjacent convex surfaces and the third and fourth piezoelectric discs having adjacent concave surfaces, the second piezoelectric disc having a concave surface adjacent a convex surface of the third piezoelectric disc.

37. The piezoelectric bending actuator according to claim 31, wherein terminals are mounted between each of the piezoelectric discs.

38. The piezoelectric bending actuator according to claim 31, wherein adjacent piezoelectric discs are oppositely poled.

39. The actuator assembly according to claim 30, wherein at least one of the piezoelectric discs is polarized in a direction opposite from the others.

40. The actuator assembly according to claim 30, wherein the polarity of the second voltage is opposite the polarity of the first and third voltage.